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PHYSICAL WORK LOAD OF WORKERS DURING PLANTING USING DIFFERENT TYPES OF DIBBLES[1]

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ABSTRACT

The aim of this research project was to compare physical work load of workers during planting of pine seedlings with the help of a dibble. The following three types of dibbles were compared: a standard IBL dibble used on light soils, a Getinga dibble and a Huffa (German) dibble. The authors measured energy expenditure and determined the magnitude of static effort and monotypic nature of operational movements of workmen planting seedlings using all the above-mentioned three types of dibbles.

The factor, which differentiated labour input applying individual types of dibbles, was net energy expenditure. It attained the highest value of 21.8 kJ/min. in the case of the applied standard IBL dibbles. The lowest value – 16.6 kJ/min. was recorded for the Huffa dibble, while in the case of the Getinga dibble, this value reached 19.0 kJ/min. The static effort and the monotypicity of operational movements were found high for all the applied types of dibbles. The planting efficiency was similar for standard and Getinga dibbles, whereas in the case of the Huffa dibble, this efficiency was higher by almost 25 %.

Key words: pine regeneration, dibbles, ergonomics, physical load.

INTRODUCTION

In forest sciences, investigations from the area of ergonomics concern mainly the evaluation of levels of psychophysical or environmental loads in the course of carrying out certain specific forest works. Research results usually provide information concerning values of loads associated with clearly specified types of operations, such as, for example: tree cutting by means of a chain saw, debranching of trees using an axe, debranching of trees using a chain saw etc. These types of investigations usually ignore possible variations of ergonomic loads in relation to the applied specific tool, for example: different types of saws used to debranch trees. This study constitutes an attempt to fill in the gap in this area of our knowledge.

In Poland, since 1939, foresters have been using the IBL dibble to plant pine seedlings both in the course of afforestation and regeneration, a practice popularised in the period after the Second World War [9,10]. However, since that time, numerous other tools for forest tree planting (A review of tools for tree planting was presented in the Grube Company Catalogue [2].) have been devised and applied in various parts of the world. As to the scarce available Polish literature references on the subject of onerousness of planting with the aid of a dibble, they all refer to the standard dibble [5,6].

The purpose of the performed investigations was to assess and compare the physical load of workers using different types of dibbles when planting one-year old pine seedlings in the course of renovation of clear-cut areas. The obtained results should allow to increase the level of labour humanisation of forest workers employed to plant seedlings. At the same time, the performed studies broaden the scope of knowledge concerning tools commonly used in silviculture.

METHODS, SCOPE AND AREA OF INVESTIGATION

The physical work load imposed on the human organism has a decisive influence on the degree of labour onerousity. One of its basic elements is a dynamic physical effort, which can be measured by energy expenditure defining the quantity of energy used to perform a given task [8]. Attempts were even made to estimate the labour load exclusively on its basis [3]. The remaining components of the physical load include: static effort and monotypicity of operational movements, which may exert a varying effect on the degree of onerousity, depending on the character of the performed task.

In the course of these investigations, the following parameters were determined:

1. Structure of a workday

In order to establish the length of individual labour operations, a continuous timekeeping was carried out which allowed to develop photography of a day's work (time of the control shift). Individual operations were classified into appropriate categories of work time in compliance with the BN-76/9195-01 standard [1].

2. Energy expenditure

A unit net energy expenditure (kJ/min.) was determined on the basis of measurements using a special energy expenditure meter MWE-1. Prior to the initiation of the measurement, a worker would work in the mask for a few minutes to get used to it and adjust his breathing. The measurement cycle consisted of 3 measurements of 5 minutes each separated by a 15-minute break. The final result was a mean from all measurements.

3. Static effort

This was determined applying the OWAS method on the basis of visual observations of the worker's body position during work and the duration of individual positions. The employed method applies a codification of positions of individual body parts (back, shoulders and legs) as well as values of outside loads. On the basis of code positions, the examined job is allocated to one of four evaluation categories, which determine the degree of position enforcement. Next, on the basis of the assessment category and the time the given position is maintained, the position is classified in a three-degree assessment system of the static load.

4. Monotypicity of operational movements

The authors assumed the planting of one seedling as a stereotype labour operation. First, the time necessary for the planting of three seedling batches of 100 pieces each was determined and then the obtained value was referred to the duration of the planting operation from the timekeeping.

The following three types of dibbles were examined during the described investigations (Fig.1): a standard IBL dibble – the variant designed for light soils, a Gõhler-Getinga dibble (A dibble with a handle shaped like the bicycle handlebar designed in Getinga. It is intended for seedlings with a naked root system with the length of the main stem of up to 1000 mm and either a taproot or narrow heart-like root system. Planting depth 250 - 300 mm [2].) and a Huffa (German) dibble (Designed for planting of coniferous seedlings having a small root system (mainly pine). Thanks to its special design, the hole does not have a "well" and the hole closes up when stepped on. Higher effectiveness. The method is both simple and certain [2].). The individual dibbles differ from one another with regard to the shape of the handle and the cutting edge as well as weight (Tab.1). Getinga and Huffa dibbles are designed (according to the manufacturer's recommendation) in such a way as to allow single-person planting. However, in the discussed investigations, the authors employed a two-person technique commonly applied in Poland (IBL system of dibble planting) with one modification, namely, in the case of Huffa dibble, the opening with the seedling in it was closed by the helper. In the meantime, the worker operating the dibble was making a hole for the next seedling.

Investigations were carried out in the area of Oborniki Wielkopolskie Forest Division, Podlesie Forest Range, section 490b, area 4.03 ha, fresh mixed coniferous site type, plain area, rusty-podzolic soils, soil sediments – loose sands. The area was prepared in the autumn of the previous year. The preparation consisted of ploughing of furrows and loosening of the soil in furrows using a subsoiler. The investigations were performed at the beginning of April 2001 and the air temperature was 15°C.

Fig. 1. Dibbles used in the described experiment. Left to right: standard IBL dibble, Getinga dibble and Huffa (German) dibble

Table 1. Parameters of dibbles applied in the experiment

Dibble type	Height (m)	Weight (kg)	Wedge length (m)
Standard IBL	0.95	4.00	0.35
Getinga	1.00	4.88	0.40
Huffa (German)	0.98	2.40	0.22

Two working teams (male) took part in the experiment and each team consisted of two persons – a dibbler and a helper carrying seedlings. Each team worked with all the examined types of dibbles. The worker operating the dibble made openings and when the helper placed a seedling in the hole, the dibbler closed it pulling the dibble towards him. In the case of the Huffa (German) dibble, the opening was closed by the helper, who pressed the soil with his foot.

The results presented bellow are means obtained by the two experimental working teams.

RESULTS

In order to allow a comparison of results, duration times of consecutive operations for all of the examined tool variants were averaged. The work of the dibbler (the one making openings) is not much varied and the number of labour operations performed by the worker is low. The planting operation (effective work time) took up 73% of the work shift (8 h), while the remaining time included assisting operations and rest (Tab. 2).

Table 2. Structure of working time during planting of pine seedlings using a dibble

Work time category	Type of operation	Duration (min)	Share (%)
T1 – effective time	Planting – standard dibble	350	73.0
	Planting – Getinga dibble		
	Planting – Huffa dibble		
T_2 – assisting operations	Movements	30	6.2
	Technological break	37	7.7
T_5 – rest time	Rest break	54	11.2
T_8 – non-assignable time losses	Organisational break	9	1.9
T_{08} – time of the control shift	-	480	100.0

The amount of energy necessary to carry out appropriate operations with individual types of dibbles varied. The highest energy expenditure was recorded in the case of the worker using the standard dibble and its unit net energy consumption reached 21.8 kJ/min. The appropriate values for the remaining two dibbles were as follows: 19.0 kJ/min. for the Getinga dibble and 15.6 kJ/min. – for the Huffa dibble.

The energy expenditure during a work shift was determined on the basis of duration of individual operations (work, assisting operations, breaks) and unit load magnitudes (Tab. 3). During the control shift, the energy expenditure of a worker working with the dibble varied and ranged from 6460 kJ for the Huffa dibble to 8630 kJ, when work with the standard IBL dibble was involved (Fig. 2). The net energy cost of planting one seedling was found to be as follows: 2.22 kJ for the standard IBL dibble, 1.90 kJ – for the Getinga dibble and 1.27 kJ – for the Huffa dibble. A daily energy expenditure for helpers was similar for all types of dibbles and averaged 5800 kJ.

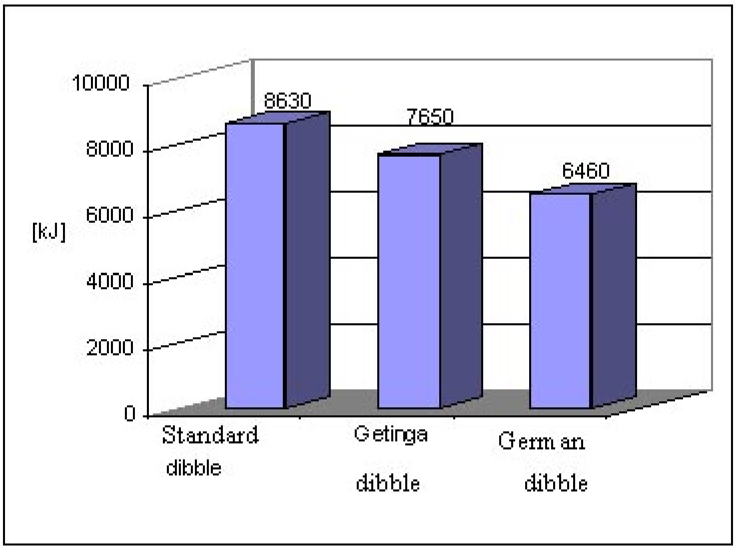
Table 3. A list of unit values of net energy expenditures during planting of pine seedlings using different types of dibbles

Type of operation	Net mean energy expenditure (kJ/min)	Standard deviation	Variability coefficient
Work with standard dibble	21.8	0.70	3.21
Work with Getinga dibble	19.0	1.05	4.82
Work with German dibble	15.6	0.91	5.83
Movements	22.8	2.05	8.99
Rest break	3.6	0.35	9.72
Organisational break	5.2	0.42	8.08
Technological break	5.2	0.42	8.08

The type of the applied dibble did not have any influence on the degree of static effort of the worker. The work of all the examined types of dibbles was classified as loaded with a high degree of static effort. This assessment was strongly influenced by the duration of planting operations in the structure of the workday (over 70%). However, the value of static loads was not found to have been affected by differences in the weight of individual types of dibbles because differences in their weights were small and the weight of the examined tools never exceeded 5 kg.

Planting is a monotonous operation and is characterised by a considerable repeatability. The observed monotypicity of operational movements is quite considerable (more than 3200 repetitions per work shift). The authors assumed the planting of one seedling as a stereotype work operation, consequently, the value describing the monotony of labour simultaneously refer to the number of seedlings planted during one workday (Tab. 4). In the case of planting with IBL and Getinga dibbles, the number of repetitions was at least twice higher than the number of planted seedlings because the worker making openings with the dibble had to prod the dibble once more in order to close the gap with the seedling (when Huffa dibble was employed to plant seedlings, the opening containing the seedling was closed by the helper who stepped his foot on the soil near the hole to do it).

Fig. 2. Energy expenditure of a dibbling worker for different types of dibbles in the course of an 8-hour work shift



In the case of a standard IBL or Getinga dibble, the planting efficiency was similar and amounted to approximately 3500 pieces/8h. On the other hand, the efficiency of the Huffa dibble was higher and one worker planted up to 4286 seedlings per shift.

Table 4. Planting efficiency of one-year old pine seedlings using a dibble (number of repetitions of work operations) in the course of one 8-hour work shift

Dibble type	Number of planted seedlings during 8 hours of work	Time of planting of 1 seedling (s)
Standard IBL	3443*	6.1
Getinga	3500*	6.0
Huffa	4286	4.9

*without additional prodding of the dibble in order to close the fissure

DISCUSSION

In the review of results from literature on the subject, Józefaciuk and Nowacka [6] report that the gross energy expenditure of workers operating a standard IBL dibble ranged from 23.02 kJ to 46.05 kJ, whereas Jasnos [5] reports the net level of 4.45 kcal/min. (18.6 kJ/min.). The results obtained in the course of experiments described in this study (respectively: 21.8 kJ, 19.0 kJ and 15.6 kJ) are among the lowest load values found in literature and in the case of the Huffa dibble (15.6 kJ) – far below the referred values.

Differences in the quoted values of energy expenditure during work with dibbles could be attributed to the following causes:

- Different depths to which the cutting edge was prodded into the soil (the length of the cutting edge in a standard dibble for light soils is 35 cm and is rarely used in full),
- Type and compactness of soil in a given afforested area,
- Differences in dibble parameters (its weight, width, angle of cutting edge),
- Differences in organism efficiency of individual workers,
- Application of insufficiently precise research methods.

In order to restrict the risk of error occurrence in the discussed investigations, an identical research method was applied for all the examined types of dibbles. On the other hand, the effect of individual personal characters on the obtained results was limited by making all workers operate at types of dibbles.

Differences in energy expenditures in the course of work with individual types of dibbles used in this study can be attributed to their different weight, cutter tip angle and – closely associated with it - the value of force necessary to drive the wedge into the soil but also to the different technique of planting. Even though standard IBL and Getinga dibbles are characterised by similar weights, the amount of energy utilised during one minute of work with the latter type of tool is by 2.8 kJ smaller because, due to the application of a flat wedge in the Getinga dibble, less energy is required to drive the tool into the soil and make the appropriate opening.

The Huffa dibble is significantly lighter than the other two types of dibbles. An additional effect is achieved in the result of the application of a different planting technique in which the worker operating the dibble makes only the opening (a single dibble prod), while the helper closes the hole by pressing the soil with his foot. This means that there is no additional jab of the dibble into the soil in order to close the crevice.

The planting of pine seedlings with the use of a dibble is characterised by high labour efficiency (planting), which affects the degree of its onerousness. It can be reduced by appropriate work organisation and consistent distribution of breaks during a work shift. A similar proportion of effective labour occurs in the majority of handwork characterised by simplicity and low effort, e.g. cutting of grass in plantations, early thinning [4].

Operating the standard dibble with the energy expenditure of the order of 8630 kJ per work shift ranks it in the category of very hard works as it exceeds physiological standards by over 200 kJ [7]. The use of the Getinga dibble, and even more so of the Huffa one, allows restricting the energy expenditure and reduce the category of labour onerousness by one degree (hard work).

CONCLUSIONS

1. The type of the dibble used for planting exerts influence on the value of the physical load of workers operating a given type of dibble.
2. Work with the commonly applied standard IBL dibble results in the highest energy loads of workers (net expenditure of 21.8 kJ) in comparison with all the three examined types of dibbles. The lowest energy costs were observed in the case of work with the Huffa dibble (net – 15.6 kJ).
3. Irrespective of the applied type of dibble, a high static effort and monotypicity of operational movements were observed.
4. In comparison with the standard IBL dibble, the use of the Huffa (German) dibble allowed to reduce workers' energy expenditures during planting by 25%.
5. Labour efficiency in the case of the Huffa dibble is by nearly 25% higher in comparison with IBL and Getinga dibbles.

REFERENCES

1. BN-76/9195-01. Maszyny rolnicze. Podział czasu pracy. Symbole i określenia. [Agricultural machines. Working time division. Symbols and determinations] [in Polish].
2. Ceitel J., Orlikowska E. H. 2000. Narzędzia do sadzenia. [W]: Katalog GRUBE, leśnictwo, drzewnictwo, rolnictwo, ogrodnictwo, parki. [Planting tools [In]: Grube Company Catalogue, forestry, woodworking, agriculture, horticulture, parks], pp. 163-174 [in Polish].
3. Ejsmont J. 1996. Wpływ modernizacji stanowisk pracy na obniżenie wydatku energetycznego pracowników zakładów ceramicznych. [Effect of workplace modernisation on decreasing energy expenditure of workers in a ceramic factory]. Medycyna pracy 47 (2), pp. 163-167 [in Polish].
4. Giefing D. F., Hołota R., Szaban J., Grzywiński W., Kosak J. 2001. Opracowanie charakterystyk prac leśnych w zakresie ich bezpieczeństwa, szkodliwości i uciążliwości. Opracowanie końcowe. [Evaluation of forest work with respect to safety, harmfulness and arduousness. Final study]. Katedra Użytkowania Lasu AR w Poznaniu, 98 pp. [in Polish].
5. Jasnos P. 1998. Ocena ergonomiczna. Wybrane praktyczne i teoretyczne problemy badań uciążliwości pracy. [Ergonomic estimation. Selected practical and theoretical problems of work's arduousness]. Zastosowania ergonomii 1, pp. 33-38 [in Polish].
6. Józefaciuk J., Nowacka W. 1999. Ćwiczenia z ergonomii i ochrony pracy. [Ergonomics and work safety]. Wyd. SGGW, 80 pp. [in Polish].
7. Konarska M. 1985. Wydatek energetyczny. [The energy expenditure]. Bezpieczeństwo pracy 4, pp. 3-6 [in Polish].
8. Koradecka D., Sawicka A. 1987. Ocena obciążenia organizmu pracą fizyczną. [Physical work load estimation of the human body]. Bezpieczeństwo pracy 11, pp. 9-14 [in Polish].

9. Królikowski L. 1947. Sadzenie jednorocznej sosny w szparę. [Slit planting of one-year old pine seedlings]. Prace IBL, ser. C, 22 [in Polish].
10. Królikowski L. 1953. Badania pracy kostura w zależności od jego kształtu. [Investigations of working use of a notching wedge in relation to its shape]. Prace IBL, 91 [in Polish].

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